

D.) AMENDMENTS TO THE DRAWINGS

None.

E.) REMARKS

This Response is filed in response to the Office Action dated December 8, 2006.

Upon entry of this Response, claims 1-20 and 28-31 will be pending in the Application.

In the outstanding Office Action, the Examiner rejected claims 1-18 and 28-31 under 35 U.S.C. § 103(a) as being unpatentable over Tani (U.S. Publication No. 2003/0145934) hereinafter "Tani" in view of Hillig et al. (U.S. Patent No. 4,917,941), and rejected claims 19 and 20 under 35 U.S.C. § 103(a) as being unpatentable over Tani in view of Hillig et al. in further view of Colegrove et al. (U.S. Patent No. 6,096,669) hereinafter "Colegrove".

Rejection under 35 U.S.C. 103

A. Claims 1-18 and 28-31

The Examiner rejected claims 1-18 and 28-31 under 35 U.S.C. § 103(a) as being unpatentable over Tani in view of Hillig.

Specifically, the Examiner stated that

a. Tani teaches a process for producing a fiber-reinforced silicon carbide composite offering high toughness comprising a multiple layer laminate (Abstract). Woven, nonwoven and unidirectional preregs of silicon carbide fiber are available to reinforce the silicon carbide matrix [0014, 0015]. The voids between the fibers of each layer of the composite are filled with polymeric resins and silicon. Following heat-treatment the tow components from a porous silicon carbide matrix that link the fibers of each layer of the laminate (Abstract, [0006]). The laminate of Example 3 comprises two layers of nonwoven silicon carbide fabrics laminated in alternating order creating a laminate combination of nonwoven/woven/nonwoven/woven. Unidirectional fiber preregs, which comprise continuous fibers, may replace the woven fabric layers [0014]. Replacing the woven fabric layers of Example 3 with unidirectional fiber prepreg layers creates a ceramic matrix composite laminate with a nonwoven layer in between two layers of unidirectional fiber prepreg. The invention of Tani is silent as to the use of chopped ceramic fibers in the creation of the nonwoven fabric layer.

The Examiner then added a secondary reference stating

Hilleg et al. teach a fiber and a filament containing ceramic perform comprised of a mixture of discontinuous fibers surrounding a layer of continuous filaments extending through the mixture. The mixture is produced by and infiltrated with a molten ceramic to produce a composite (Abstract). The continuous fibers provide reserve strength to the composite should it crack and the discontinuous fibers provide toughness to the composite (col. 1, line 61-col. 2, line 12). The discontinuous fibers may be chopped silicon carbide fibers or a mixture of different ceramic fibers (col. 3, lines 1-20). The continuous fibers may be made of silicon carbide or a mixture of different ceramic fibers (col. 5, lines 43-49). Hillig et al. also show that it is advantageous for the ceramic matrix to comprise at least 50 percent of the chopped fiber layer (col. 11, lines 10-14). Therefore,

claims 12 and 13 are rejected.

The Examiner further stated

The structure of the applied article has a layer containing a plurality of continuous ceramic filaments adjacent a layer of chopped ceramic fibers located in a continuous matrix phase which is adjacent another layer containing a plurality of continuous ceramic filaments (claim 5).

The Examiner continued

A number of chemical species are available for use as the infiltrant to create the continuous matrix including ceramics (col. 4, lines 1-14). The continuous matrix phase is to be distributed evenly throughout the composite to create the instantly claimed infiltrated article (col. 11, lines 6-13). Claim 5 is rejected as the ceramic fibers may have a length of from about 10 to about 2000 microns (0.0004 to 0.08 inches)(col. 3, lines 13-15). Claim 14 is rejected as the ceramic chopped fibers have diameters up to 10 microns (0.0004 inches)(col. 3, lines 10-15).

The Examiner further continued

Claims 8-11 are rejected as the matrix phase of the applied invention is designed to fill the space the between adjacent layers of continuous filaments thereby reducing the number of inter-laminar voids, size and volume fraction of said voids. The most preferred embodiment is a completely pore-free composite (col. 10, lines 61-64).

The Examiner further continued

Since Tani and Hillig et al. are from the same field of endeavor (i.e. fiber-reinforced silicon carbide composites), the purpose disclosed by Hillig et al. would have been recognized in the pertinent art of Tani.

The Examiner then added a motivation statement continuing

It would have been obvious at the time the invention was made to a person having ordinary skill in the art to have made the nonwoven layers of Tani with the chopped ceramic fibers of Hillig et al. and formed a composite without any remaining voids. The skilled artisan would have been motivated by the desire to provide the composite with toughness (col. 1, line 61-col. 2, line 12, Hillig et al.).

The Examiner further continued

Claim 2 is rejected as Hillig et al. teach a chopped fiber mat thickness of 0.02" (Example 1). Tani and Hillig et al. disclose the claimed invention except for the nonwoven mat thickness of claim 3. It would have been obvious to one having ordinary skill in the art at the time the invention was made to have made a thinner nonwoven mat layer between 0.0001 and 0.0002 inches thick, since it has been held that where the general conditions of a claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. *In re Aller*, 105 USPQ 233. A thinner nonwoven mat would allow for the stronger unidirectional fiber layers to make up more of the ceramic composite improving its total strength.

Claim 4 is rejected as the discontinuous fibers of the chopped fiber layer of Hillig et al. are randomly oriented and then infiltrated with ceramic matrix.

Applicants respectfully traverse the rejection of claims 1-18 and 28-31 under 35 U.S.C. § 103(a).

Tani, as understood, is directed to a process of producing a multi-layer fiber-reinforced silicon carbide composite having an amount of toughness.

In contrast, amended independent claim 1 recites an improved ceramic matrix composite laminate comprising a plurality of preform lamina, each of the preform lamina being formed of directional continuous ceramic fiber in a ceramic matrix; an infiltrated nonwoven mat including a plurality of chopped ceramic fibers in a ceramic matrix, the nonwoven mat being interposed between adjacent preformed continuous fiber lamina of the plurality of preform lamina to form an interface between the continuous fiber lamina which reduces voids and prevents a continuous, stratified matrix rich layer between adjacent continuous fiber preform lamina; and wherein the ceramic matrix of the preform lamina and of the layer of nonwoven mat has been infiltrated into the preform lamina and the woven mat, the infiltrated nonwoven mat being formed by having a ceramic material fill the void spaces of a dry, porous nonwoven mat preform, the ceramic material filling the void spaces being substantially free of voids and substantially free of continuous, stratified matrix rich layer between adjacent continuous fiber preform lamina.

Further in contrast, amended independent claim 28 recites an improved ceramic matrix composite laminate comprising a plurality of preform lamina, each of the preform lamina being formed of directional continuous ceramic fiber in a ceramic matrix; an infiltrated nonwoven mat including a plurality of randomly oriented chopped ceramic fibers in a ceramic matrix, the infiltrated nonwoven mat being compressively interposed between adjacent preformed continuous fiber lamina of the plurality of preform lamina, wherein the layer is formed from a dry, nonwoven mat preform, the nonwoven mat forming an interface between the continuous fiber lamina; and wherein a matrix of compatible ceramic material has been infiltrated into the preform lamina and the nonwoven mat to form the ceramic matrix composite laminate, the infiltrated nonwoven mat having ceramic material filling the void spaces of a dry, porous nonwoven mat preform, the ceramic material filling the void spaces being substantially free of

voids and substantially free of continuous, stratified matrix rich layer between adjacent continuous fiber perform lamina.

Several of the features recited by Applicant in independent claim 1 and 28 are not taught or suggested by Tani in view of Hillig et al.

As an initial matter, “[t]he mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art suggests the desirability of the combination.” See Manual of Patent Examining Procedure, 8th Edition (MPEP), Section 2143.01.

The Examiner is reminded that “[i]f the proposed modification or combination of the prior art would change the principle or operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims *prima facie* obvious.” See MPEP, Section 2143.01.

To establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974). “All words in a claim must be considered in judging the patentability of that claim against the prior art.” *In re Wilson*, 424 F.2d 1382, 1385, 165 USPQ 494, 496 (CCPA 1970). If an independent claim is nonobvious under 35 U.S.C. 103, then any claim depending therefrom is nonobvious. *In re Fine*, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988).

See Manual of Patent Examining Procedure, 8th Edition (MPEP), Section 2143.03.

Additionally, the following principle of law applies to all Section 103 rejections. MPEP 2143.03 provides “To establish prima facie obviousness of a claimed invention, all claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974). All words in a claim must be considered in judging the patentability of that claim against the prior art. *In re Wilson*, 424 F.2d 1382, 1385, 165 USPQ 494, 496 (CCPA 1970).” [emphasis added] That is, to have any expectation of rejecting the claims over a single reference or a combination of references, each limitation must be taught somewhere in the applied prior art. If limitations are not found in any of the applied prior art, the rejection cannot stand. In this case, the applied prior art reference, applied individually, clearly do not arguably teach some limitations of the claims.

Applicant agrees that Tani discloses a fiber reinforced silicon carbide composite. Applicant finds that Tani further discloses that the composite may be formed by laminating woven and nonwoven prepregs. The nonwoven prepregs are described as matrix prepregs formed by impregnating nonwoven fabric with a slurry and drying to form the matrix prepregs. The composite is formed by laminating woven and nonwoven prepregs, molding under heat to a desired shape, carborizing, followed by repeated impregnating/carborizing to form the composite [0020-0025].

The Examiner states that Tani is silent as to the use of chopped fibers as the nonwoven prepreg material, and brings in the secondary reference to Hillig et al. to cure this deficiency.

Hillig et al. fails to cure Tani.

Hillig et al., as understood, is directed to a composite containing ceramic fibers. The composite may be formed by either of two methods. In a first embodiment (col. 2, lines 13-23), the composite may be formed by slip casting a suspension of fibers and liquid vehicle and impressing a layer of continuous filaments into the still wet slip casting, followed by slip casting a cover layer upon the continuous filaments. The laminate casting is then dried and infiltrated to form the composite. In a second embodiment (col. 2, lines 24-34), the slip casting suspension is first partially dried before the layer of continuous filaments is impressed. Hillig et al. further discloses that the fibers of the suspension may comprise chopped fibers (col. 3, lines 1-6). Hillig et al. further discloses that the composite may be built up of multiple alternating layers.

Thus, Hillig et al. fails to cure the deficiency of Tani for multiple reasons.

First, Hillig et al. is not concerned with forming a mass of ceramic fibers to be carborized and impregnated. The mass of Hillig et al. is dried and then impregnated to form the desired composite. Thus, the chopped fibers of Hillig et al. are used to solve a different problem than as found in Tani and the combination would change the principle or operation of the prior art invention of Tani.

Second, Hillig et al. laminates his chopped fibers between filaments that are not preforms, but are individual fiber strands. Thus, one of ordinary skill would not look to Hillig to

solve the same problem as Tani, again, the combination changing the principle or operation of the prior art invention of Tani.

Third, the chopped fibers of Hillig et al. are never prepreps to be laminated as in Tani, thus one would not expect the chopped fibers of Hillig et al. to work with a reasonable degree of success in the invention of Tani.

Fourth, even if the chopped fibers of Hillig are used to form a nonwoven prepreg in Tani, the combination still fails to teach or suggest the following limitations

"the nonwoven mat being interposed between adjacent preformed continuous fiber lamina of the plurality of preform lamina to form an interface between the continuous fiber lamina which reduces voids and **prevents a continuous, stratified matrix rich layer between adjacent continuous fiber preform lamina**" (emphasis added)

as found in claim1, and

"the ceramic material filling the void spaces being substantially free of voids and **substantially free of continuous, stratified matrix rich layer between adjacent continuous fiber preform lamina**" (emphasis added)

as found in claim 28.

Fifth, Hillig et al. does not teach or suggest a mat as recited by Applicant in independent claims 1 and 28. Hillig et al. discloses producing a suspension of a mixture of ceramic fibers and particulates in a liquid vehicle, or alternately, removing a sufficient amount of liquid vehicle from the suspension to produce a moldable mass which is molded to form a first layer of a molded compact. In either event, neither Hillig et al. embodiments can be properly considered a mat. Merriam-Webster's Collegiate Dictionary, Tenth Edition defines a mat as a piece of coarse, woven, plaited, or felted fabric used especially as a floor covering or a support, or something made up of densely tangled or adhering strands especially of organic matter. Accordingly, neither a suspension nor a moldable mass can be properly considered a mat. Furthermore, simple substituting the chopped fibers of Hillig et al. into the teaching of Tani for the nonwoven fabric does not result in a mat.

Dependent claims 2-18 and 29-31 are believed to be allowable as depending from what is believed to be allowable independent claim 1 for the reasons given above. In addition, claims 2-18 and 29-31 recite further limitations that distinguish over the applied art. In conclusion, it is respectfully submitted that claims 1-18 and 28-31 are not rendered obvious by Tani in view of Hillig et al. and are therefore allowable.

B. Claims 19-20

The Examiner rejected claims 19-20 under 35 U.S.C. § 103(a) as being unpatentable over Tani in view of Hillig, and further in view of Colegrove.

Specifically, the Examiner stated that

The invention of Tani and Hillig et al. are silent as to the use of multiple layers between the continuous fiber perform lamina.

The Examiner brought in Colegrove to teach

Colegrove et al. teach a preform suitable for use in creating a composite laminate (Abstract). Figure 5 shows an embodiment of the perform comprising a nonwoven layer 20, resin 8, and unidirectional fiber layer 10. The unidirectional fibers may be silicon carbide (col. 4, lines 24-26) and the nonwoven mat may be made of chopped silicon carbide fibers (col. 4, lines 52-55). Multiple plies of the Colegrove et al. invention may be laminated together (col. 5, lines 49-53). The lamination of two preforms of Figure 5 with the nonwoven layers 20 would result in a symmetric article with two nonwoven layer adjacent layers of resin 8, and adjacent two layers of unidirectional layers 10.

Since Tani and Colegrove et al. are from the same field of endeavor (i.e. silicon carbide fiber composites), the purpose disclosed by Colegrove et al. would have been recognized in the pertinent art of Tani.

It would have been obvious at the time the invention was made to a person having ordinary skill in the art to modify the article of Tani and Hillig et al. to include multiple layers of the nonwoven mat of Tani between the layers of directional continuous ceramic fibers. The skilled artisan would have been motivated by the desire to create an article that possesses enhanced thermal properties with the inclusion of additional chopped silicon carbide fibers. The enhanced thermal property allows the composite to have a more uniform thermal expansion, thereby decreasing the thermal stresses that buildup due to mismatched coefficient of thermal expansions between its phases.

Applicants respectfully traverse the rejection of claims 19-20 under 35 U.S.C. § 103(a).

The previous discussion of Tani and Hellig is equally applicable herein.

Colegrove, as understood, is directed to a preform suitable for resin transfer molding.

Dependent claims 19-20 are believed to be allowable as depending from what is believed to be allowable independent claim 1 for the reasons given above. In addition, claims 19-20 recite further limitations that distinguish over the applied art. In conclusion, it is respectfully submitted that claims 19-20 are not anticipated nor rendered obvious by Tani in view of Hillig et al. and further in view of Colegrove et al. and are therefore allowable.

CONCLUSION

In view of the above, Applicant respectfully requests reconsideration of the Application and withdrawal of the outstanding objections and rejections. As a result of the amendments and remarks presented herein, Applicant respectfully submits that claims 1-20 and 28-31 are not anticipated by nor rendered obvious by Tani, Hillig et al. and Colegrove or their combination and thus, are in condition for allowance. As the claims are not anticipated by nor rendered obvious in view of the applied art, Applicant requests allowance of claims 1-20 and 28-31 in a timely manner. If the Examiner believes that prosecution of this Application could be expedited by a telephone conference, the Examiner is encouraged to contact the Applicant.

The Commissioner is hereby authorized to charge any additional fees and credit any overpayments to Deposit Account No. 50-1059.

Respectfully submitted,
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